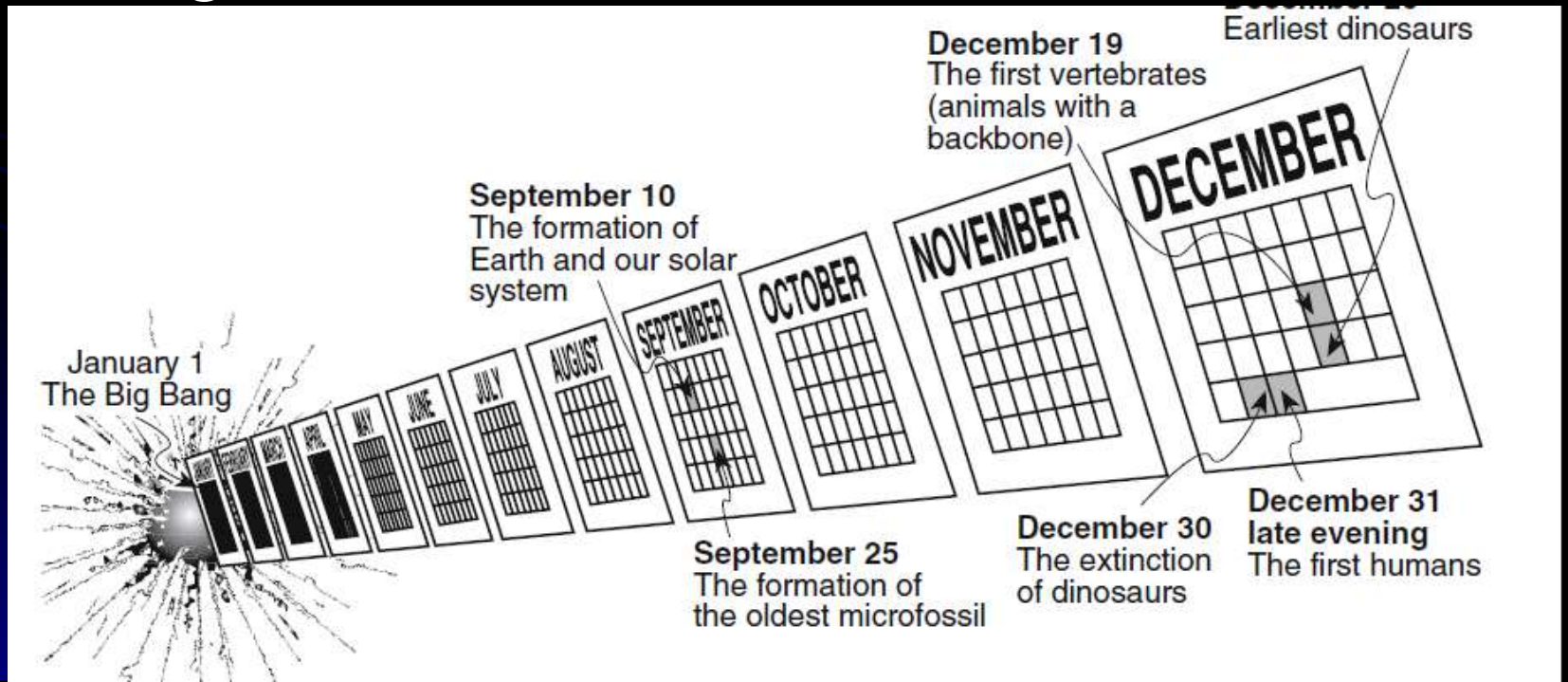
The Big Bang

Evidence of creation and expansion of the Universe through Background Radiation and Investigating Spectra (color)

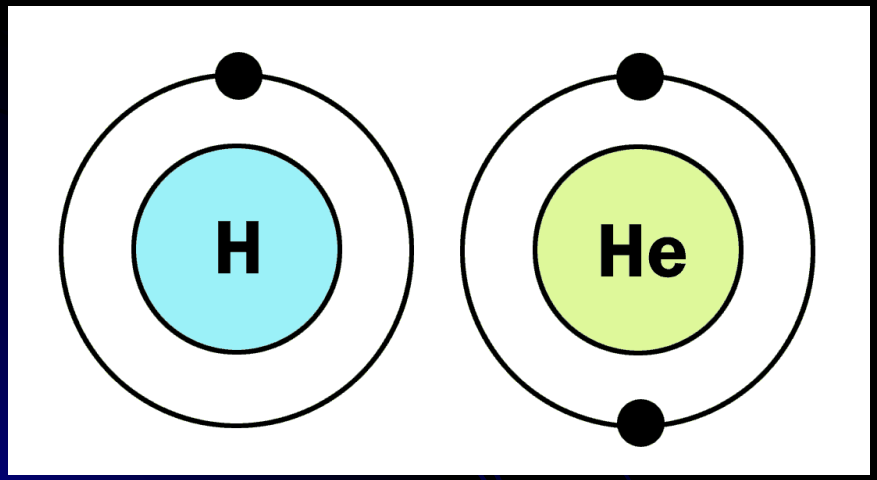
The Big Bang Video Link

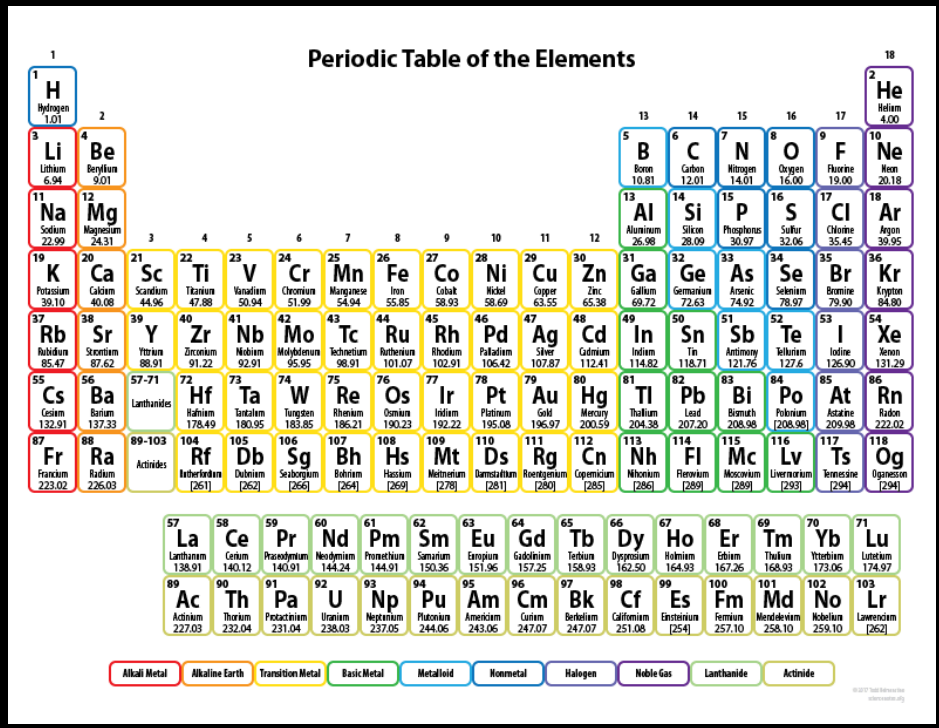
- Scientists have evidence that the universe is **13.7 billion** years old
- But it all came from one point….the big bang!



The Big Bang Theory

- States that all matter and energy started out concentrated in a small area, smaller than an atom
- After Gigantic Explosion, matter organized itself into subatomic particles and later atoms
- The first atoms to form were Hydrogen and Helium





What needed to change in order for the creation of atoms (combining of electrons, protons and neutrons)?

Data Table

Stage	Description of the Universe	Average Temperature of the Universe (°C)	Time From the Beginning of Universe
1	the size of an atom	?	0 second
2	the size of a grapefruit	?	10^{-43} second
3	"hot soup" of electrons	10^{27}	10^{-32} second
4	Cooling allows protons and neutrons to form.	10^{13}	10^{-6} second
5	still too hot to allow the forming of atoms	10^{8}	3 minutes
6	Electrons combine with protons and neutrons, forming hydrogen and helium atoms. Light emission begins.	10,000	300,000 years
7	Hydrogen and helium form giant clouds (nebulae) that will become galaxies. First stars form.	–200	1 billion years
8	Galaxy clusters form and first stars die. Heavy elements are thrown into space, forming new stars and planets.	–270	13.7 billion years

Where is our evidence for this Theory?

1.) Energy created by this explosion expanded along with the matter

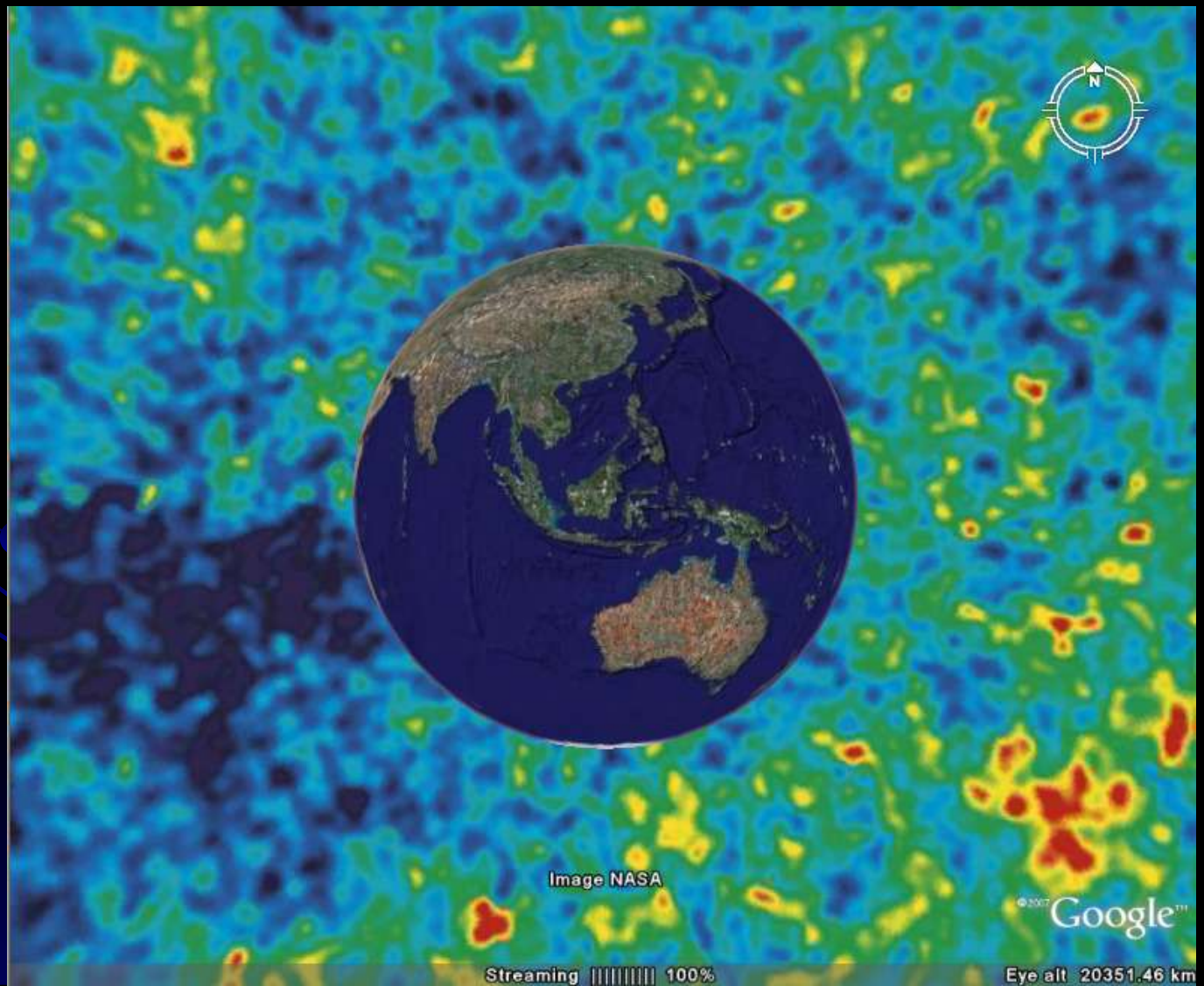
This radiation has been traveling outwards in the universe and cooling over billions of years, but can still be measured and observed.

This original radiation is called:

Cosmic background radiation (CMB) which is long-wave microwave radiation that appears to be coming from everywhere in the universe!

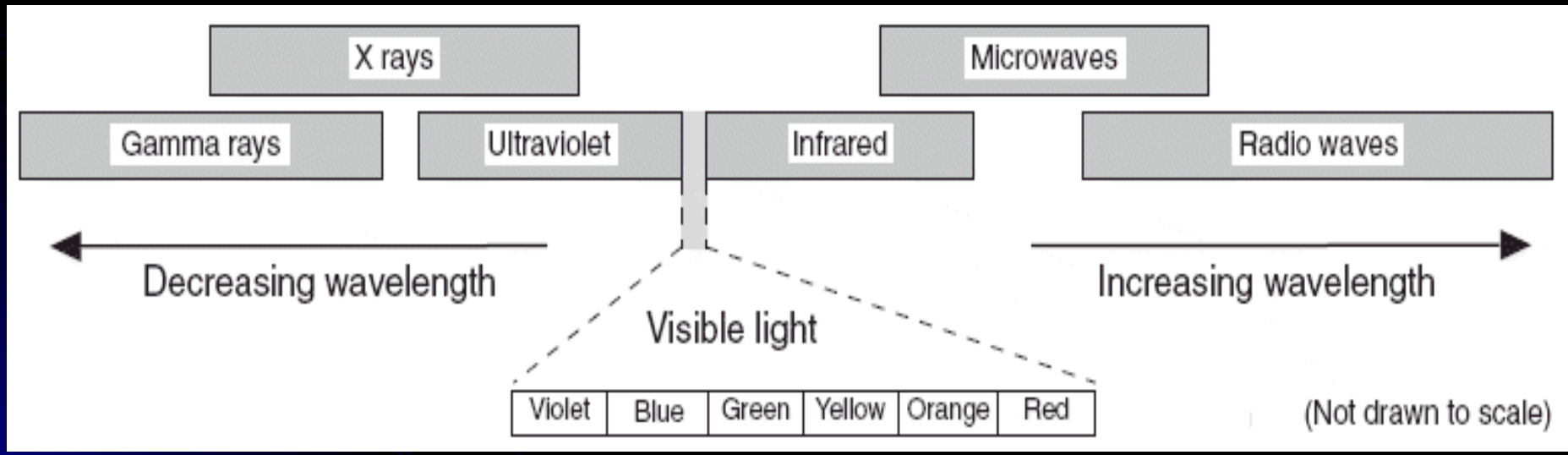
Cosmic Background Microwave Radiation

Cosmic Background Radiation Video Link



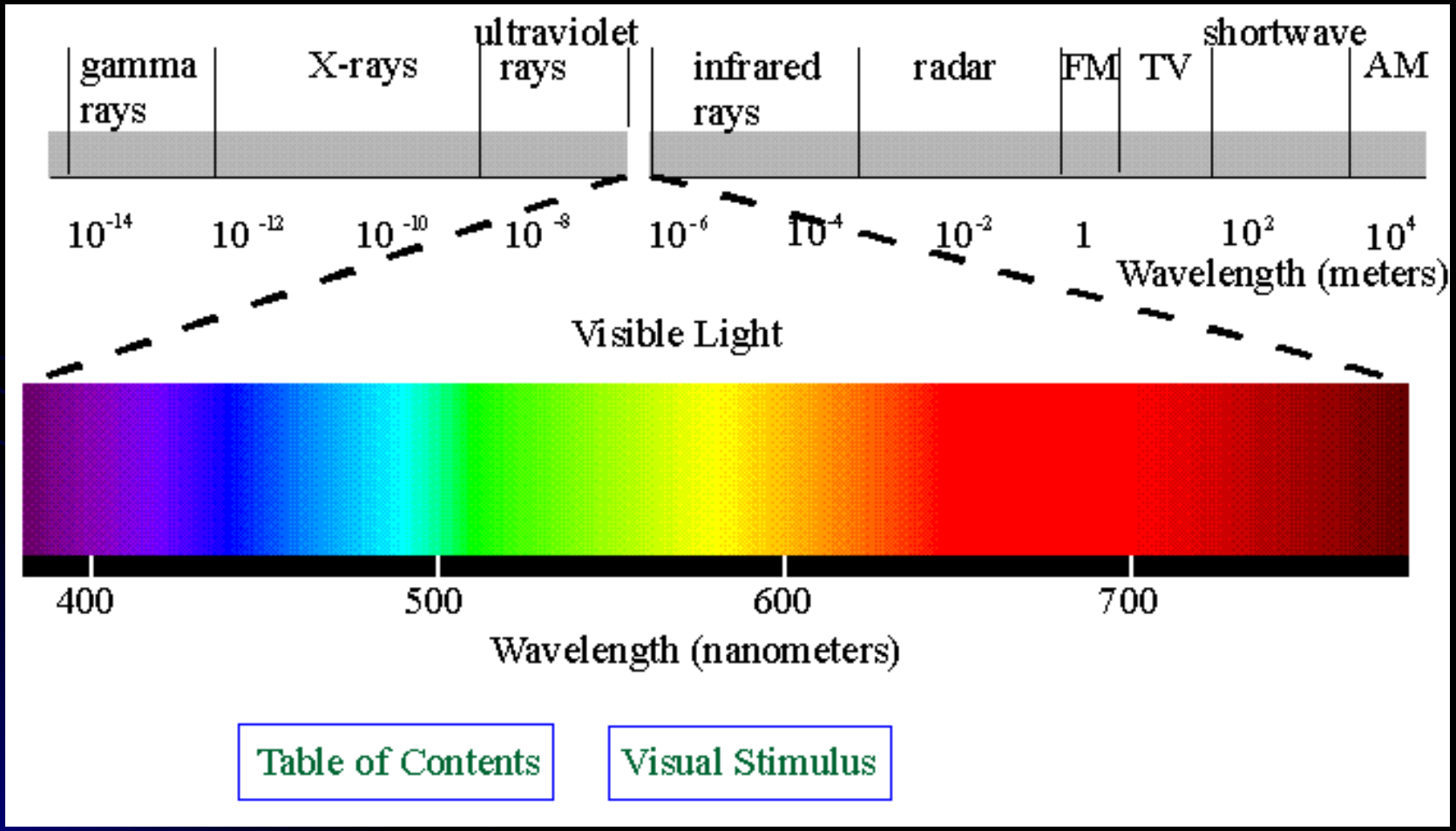
2.) **Red Shift** Exhibited by observing the spectrum of distant galaxies and stars over time

- pg. 14 of your ESRT displays the electromagnetic spectrum, or all energy produced by the sun and transmitted through radiation



Red= longest wavelength
Violet/Blue= shorter wavelengths

Analyzing Red Shift in Stars video link



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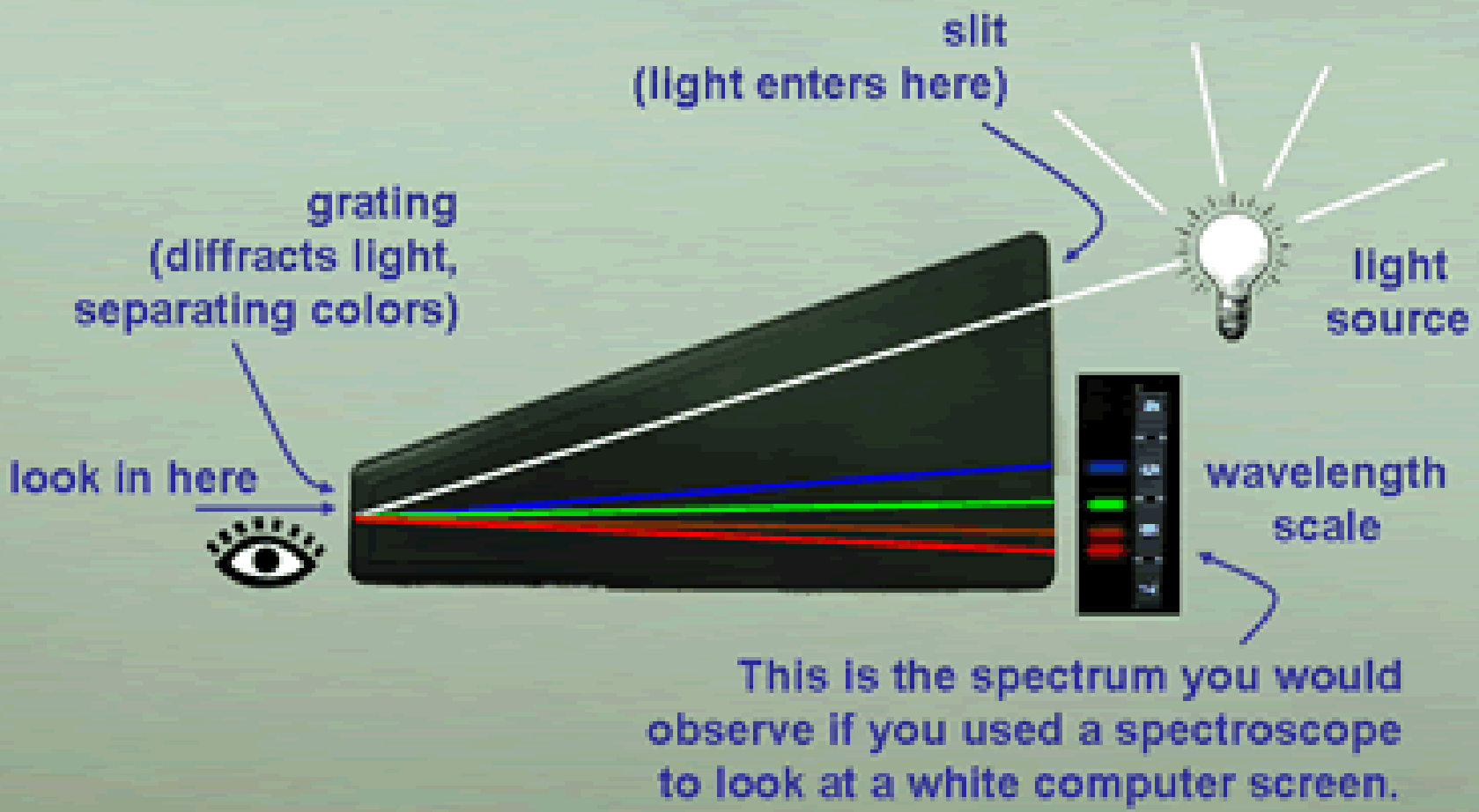
Visual Stimulus

Understanding the Spectrum

- Each **element** in the universe emits energy in **different wavelengths**
- The human eye observes **different wavelengths** of visible light in the form of **COLORS**
- We can look at the spectral signatures of stars and infer 2 things:

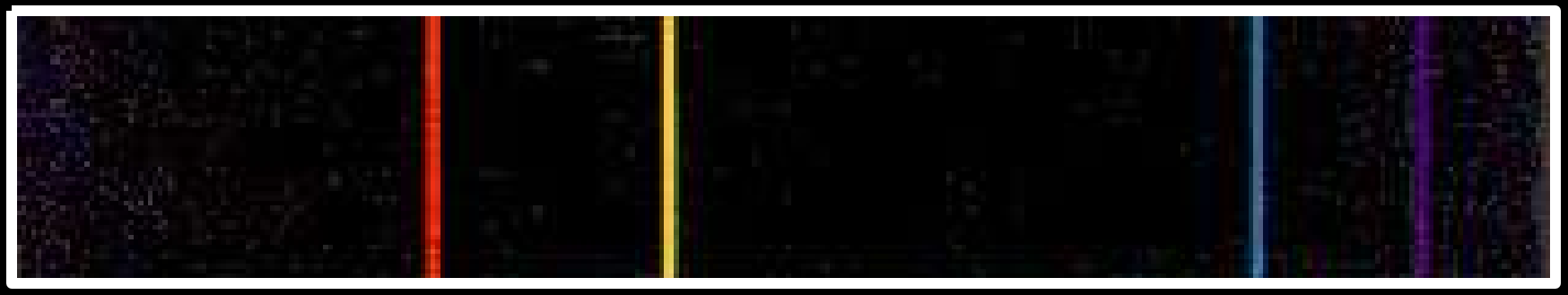
1.) Their Composition; which elements they are composed of

2.) If they are moving towards or away from us (if the spectral lines shift position with time)



How a spectroscope works

This is what lithium gas in a tube would look like through a spectroscope (The lines or “signature” tell us this is Lithium)



Each element has its own “spectrum” of color. If we saw this signature in a distant galaxy, we would know that lithium existed there

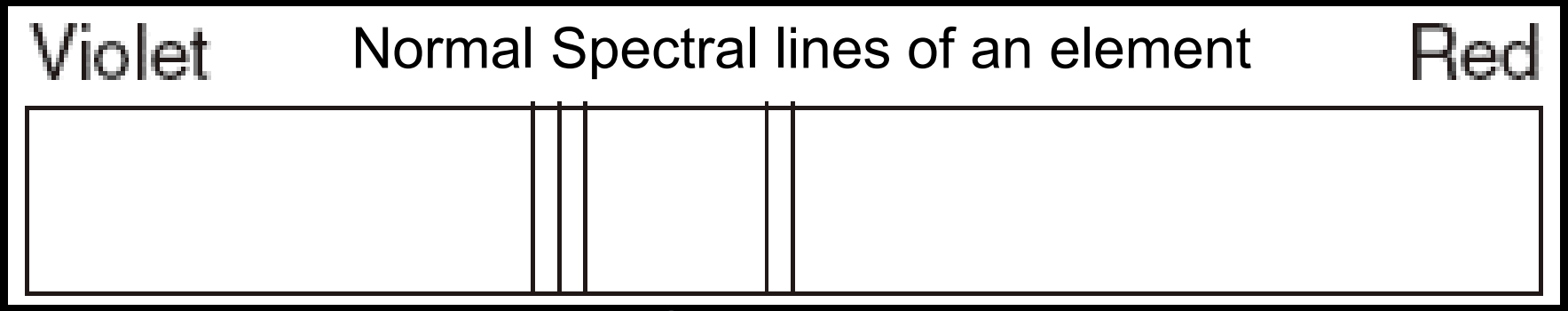
The Doppler Effect Explained (video link)

- The position of wavelengths (spectral lines), are shifted to either the

1.)shorter wavelength/BLUE side or to the

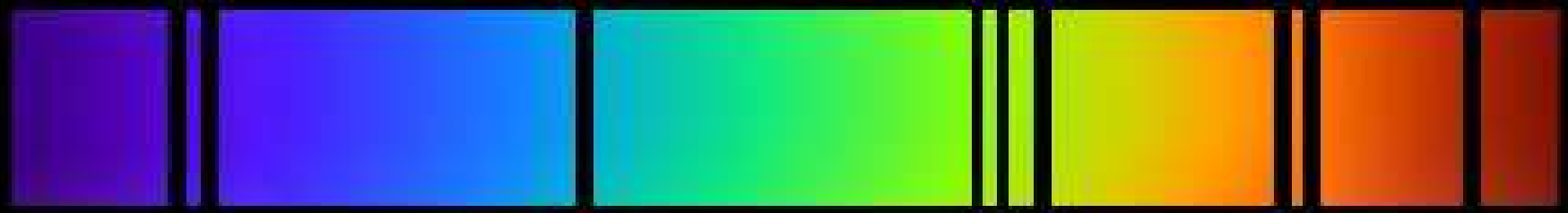
2.)longer wavelength/RED side.

- Because the universe is expanding, objects that are moving apart from one another will cause the wavelengths of energy to stretch or become longer, causing what's known as a RED SHIFT
- MOST GALAXIES SHOW A RED SHIFT

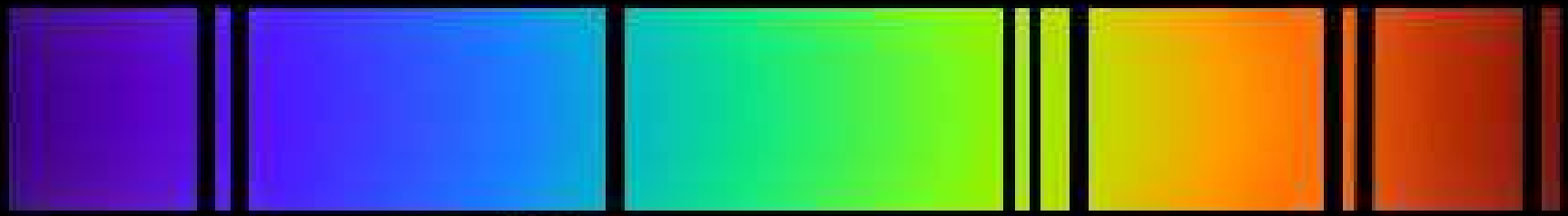


If the object were moving TOWARD us, the spectral lines would shift left (toward violet/blue end of the spectrum)

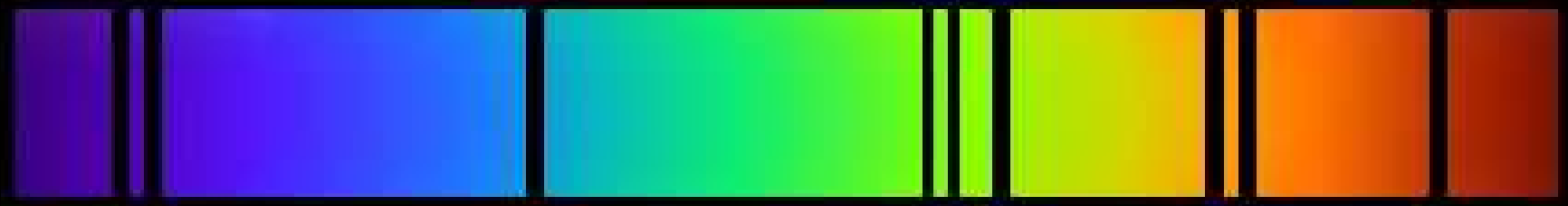
If the object were moving AWAY from us, the spectral lines would shift right (toward red end of the spectrum)



Unshifted



Redshifted



Blueshifted

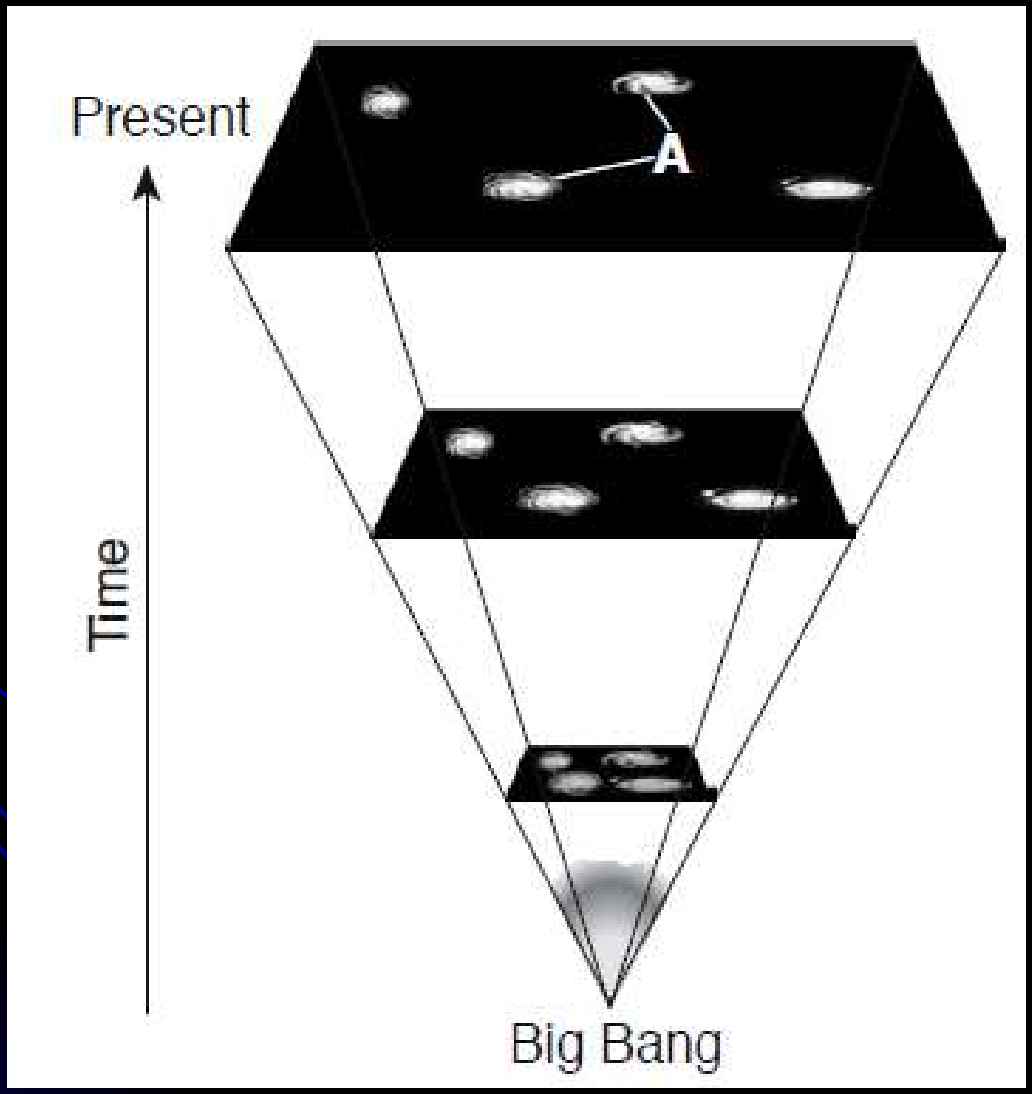
Are there any galaxies that would appear to have a blue shift?

- The Andromeda galaxy will merge with ours in the future
  - It's spectra is thus blue-shifted with time

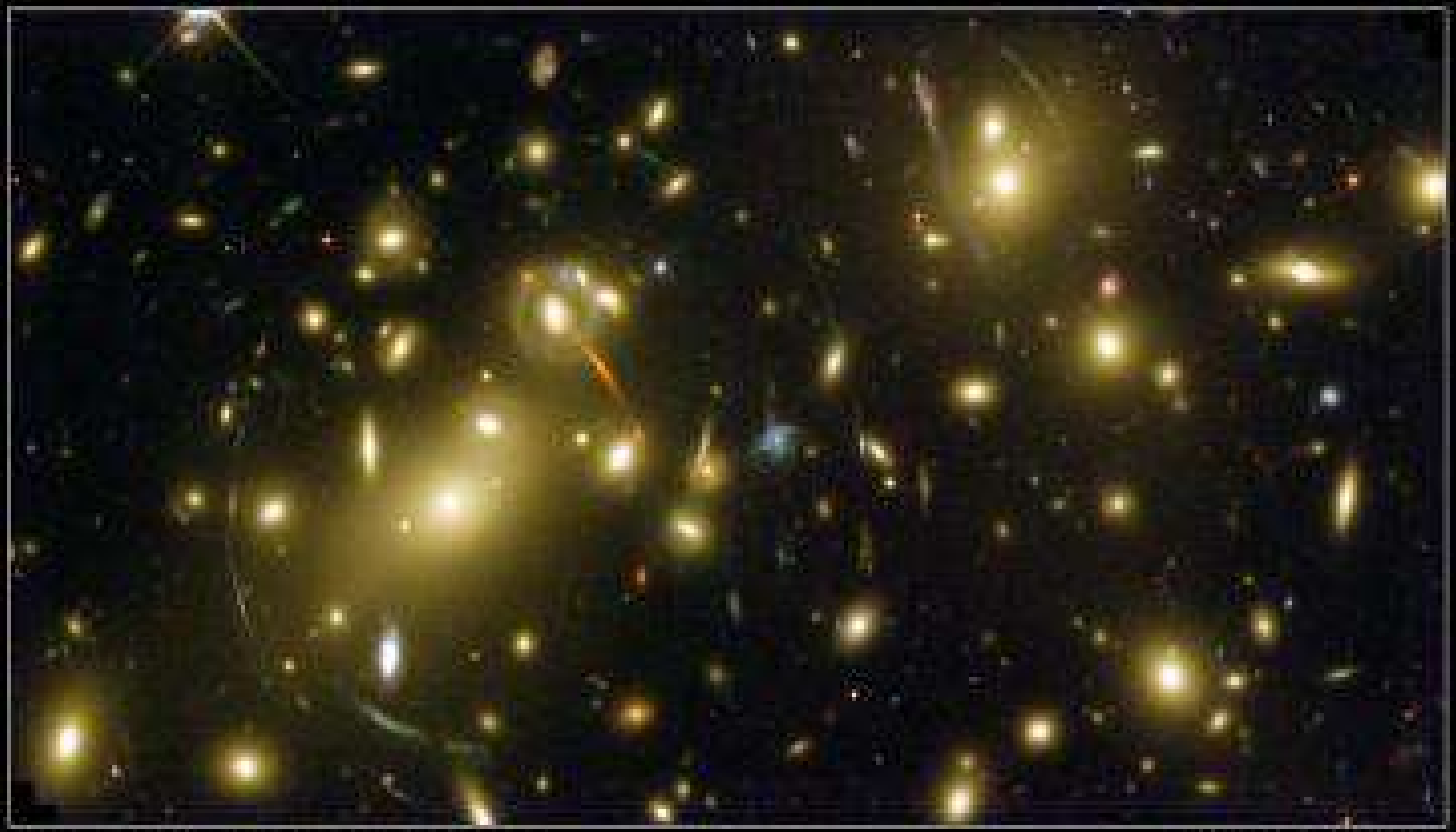
- Hubble's Law : States the Universe is Expanding!
- The faster it's expanding, the greater the red shift (further the spectral lines are shifted in the spectrum)!

Expansion of Universe

Galaxies move further apart over time



Part II: GALAXIES



Galaxy Cluster Abell 2218 HST • WFPC2

NASA, A. Fruchter and the ERO Team (STScI, ST-ECF) • STScI-PRC00-08

A Galaxy: is a collection of billions of stars

- Stars and gases are held together by gravity
- An Average galaxy will have over 100 billion stars
  - Each star (or two) with its own planetary system
- Estimated to be over 100 billion galaxies in the universe!

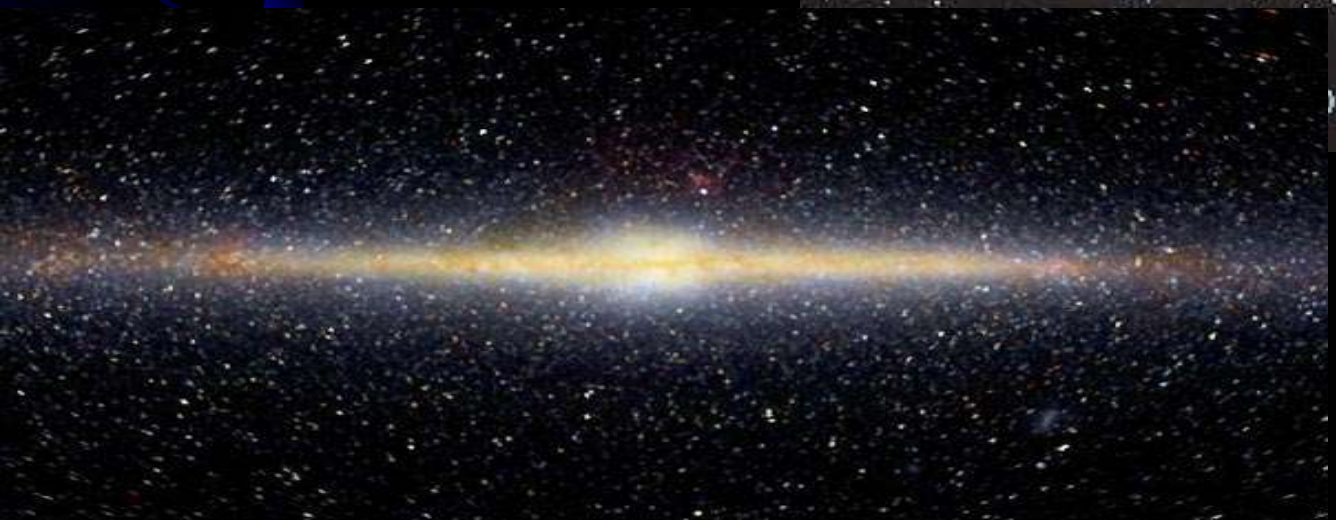
Galaxies are categorized by shape into 3 types

- 1.) Elliptical (round→football shaped)
  - Make up 60% of galaxies in the universe
  - Little to no star formation and little rotation

2.) Spiral Shaped Galaxies

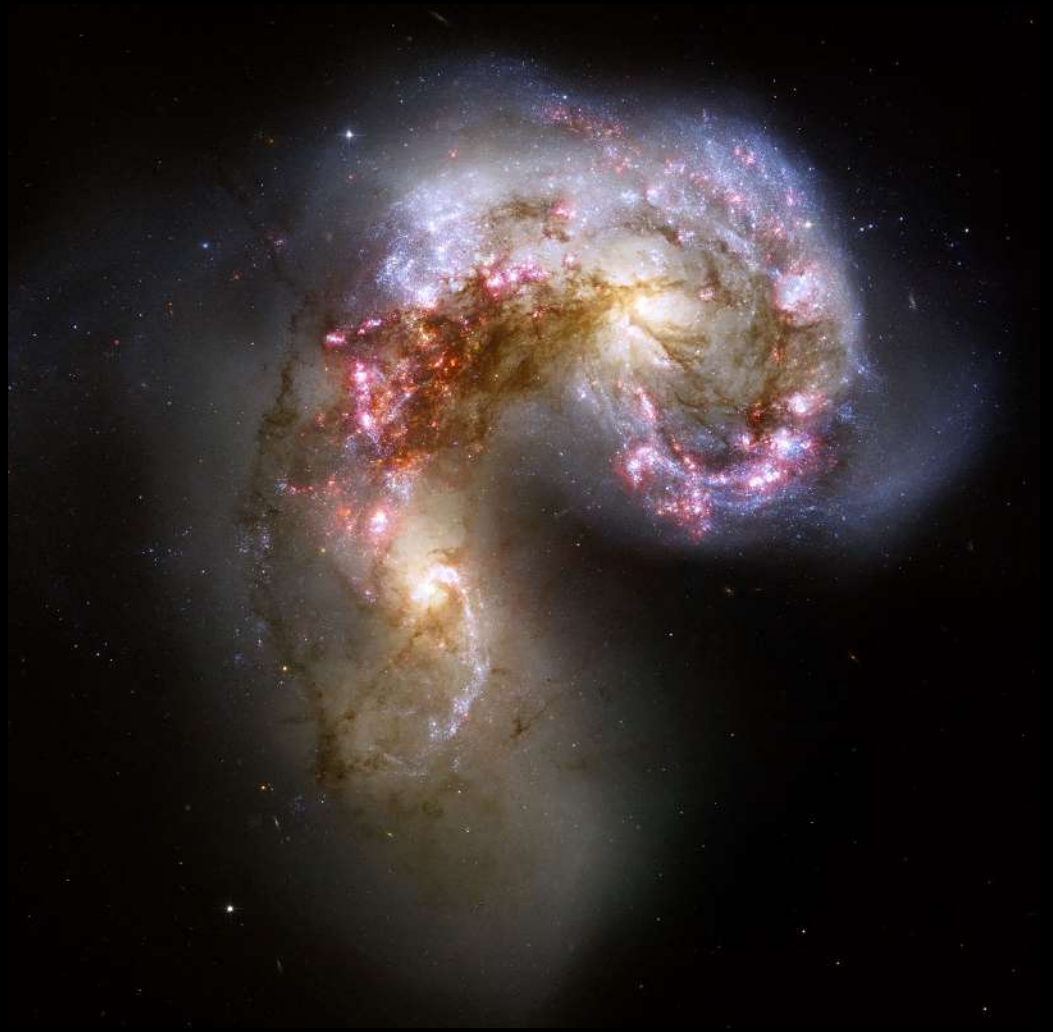
Sub groups are Spiral vs. Barred Spiral

- 30% of galaxies , contain very old and new stars
- Average size is very large
  - (25- 125 thousand
  - light years across!)



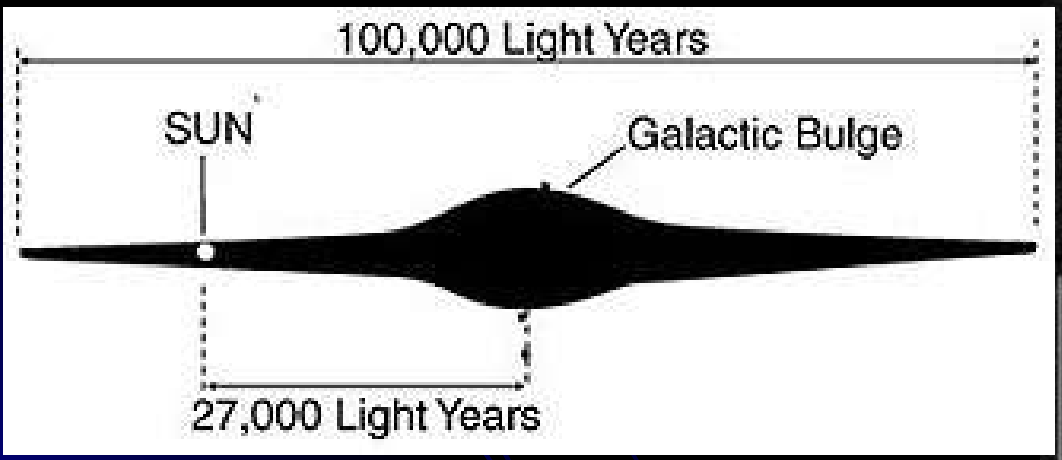
3.) Irregular Galaxies

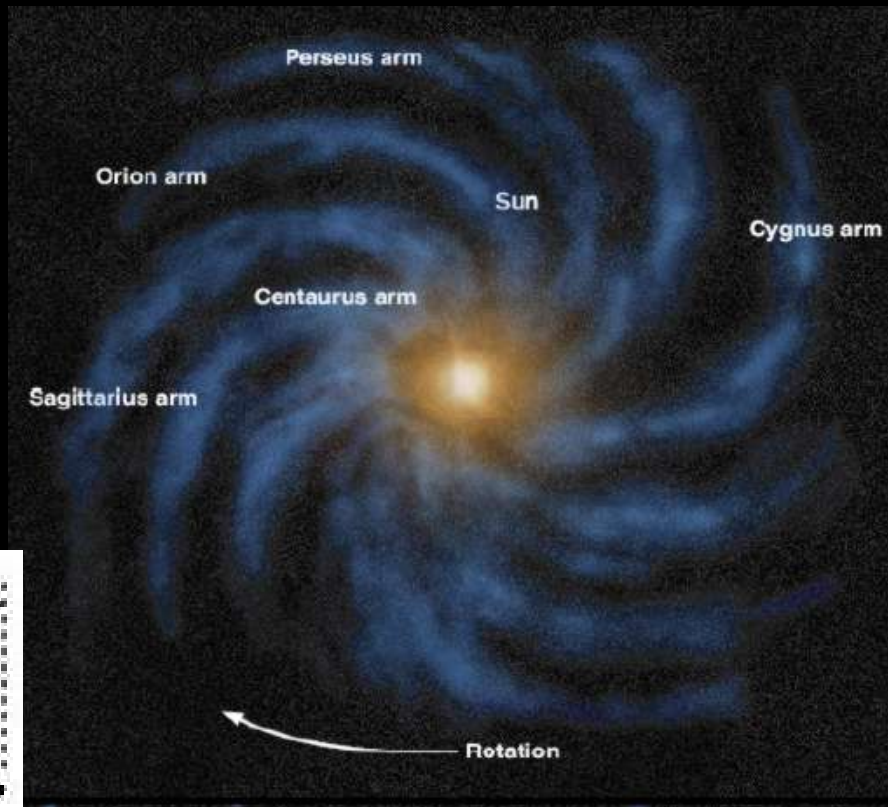
- 10% of galaxies form “irregular galaxies”
- They have no known shape
- Also contain large amounts of NEW stars

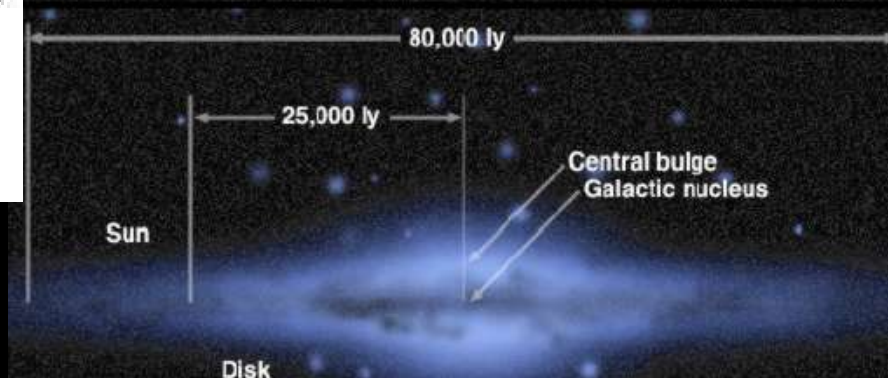


Our Galaxy: The Milky Way

- We are a spiral galaxy located on the outer edge of one of the galactic arms!







Galaxy Clusters

Like stars, galaxies can also be in clusters!

Hubble Space Telescope Gallery